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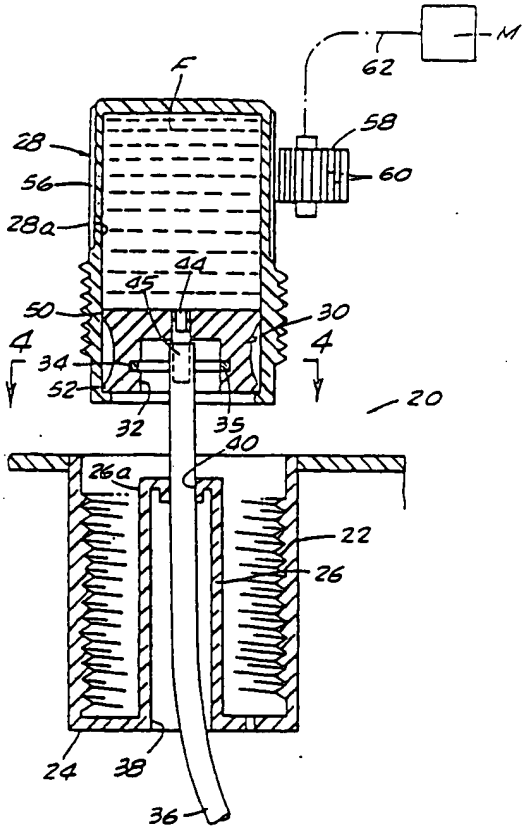
(54) Title: PRECISION LIQUID HANDLING APPARATUS

(57) Abstract

A precision reagent metering and delivery device (20) including a threaded, disposable reagent container (28) adapted to be threadably interconnected with a threaded base (22). The reagent container is provided with a fluid passageway (44) leading to the exterior thereof. Sealably mounted within the reagent container is a plunger (30) which is operably coupled with a stator (26) disposed in the base (22) so that rotation of the reagent container (28) relative to the base (22) will cause precisely predeterminable longitudinal movement of the plunger (30) within the reagent container (28) whereby the reagent (F) in the container will be controllably forced out the fluid passageway (44) in precisely determinable amounts.



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PRECISION LIQUID HANDLING APPARATUS

S P E C I F I C A T I O N

Background of the Invention

Field of the Invention -

The present invention relates generally to liquid handling apparatus. More particularly the invention concerns an improved liquid handling system for controllably dispensing, aspirating and intermixing various liquids through the use of a precision liquid metering and aspirating device having a fixed base and a rotatable fluid containing cartridge.

Discussion of the Prior Art -

There exists in the prior art a wide variety of volumetric devices for dispensing and aspirating liquids such as reagents. On one end of the spectrum is the simple manual type, such as the pipette, wherein a quantity of liquid is sucked up into a graduated tube and then discharged as a metered quantity. On the other end of the spectrum are various highly sophisticated mechanical and electromechanical devices adapted to reproducably dispense precise quantities of liquid from conventional or specially designed reagent containers. The manual type devices often lack the necessary precision, while the mechanized devices frequently are unduly complex, extremely costly and, in many instances, tend to fail or malfunction in continuous use.

The apparatus disclosed in U.S. Letters Patent No. 3,834,241 issued to Garren et al and in U.S. Letters Patent No. 4,054,061 issued to Valt are exemplary of manual type pipette devices.

The apparatus disclosed in U.S. Letters Patent No. 3,931,915 issued to Downings et al and in U.S. Letters Patent No. 4,101,283 issued to Sundstrom are exemplary of mechanical and

electromechanical dispensing devices. The latter mentioned Sundstrom device is specifically adapted for use in accurately pipetting specified digitally programmed volumes of sample and the delivery of likewise specified, digitally programmed, volumes of reagent. The thrust of the Sundstrom invention is directed toward the provision of a specially constructed plunger which is rotated within a non-threaded reagent container. Rotation of the plunger is controlled by a relatively sophisticated light-photo cell system which is operably interconnected with motor means through somewhat complex counting and connecting circuits. As a result of the particular configuration of the Sundstrom plunger, it cuts grooves in the inner wall of the reagent container as it rotates.

One of the most successful reagent metering and dispensing devices developed to date is described in the copending application Serial No. 823,939 filed by the present inventor.

The apparatus of the present invention embodies, as a subassembly thereof, the device described in Serial No. 823,939. As will be better understood from the description which follows, the apparatus of the present invention is extremely versatile and well suited for automatically performing liquid handling operations requiring the utmost precision. For example, the apparatus can be used for automated liquid sampling and analysis, for automated infusion of liquids to a patient via an access catheter, and for the precision mixing of liquids such as reagents, medical specimens, inks, paints and the like.

The apparatus is readily distinguishable from the prior art in that it solves the problems inherent in the precision aspiration and dispensing of large or small liquid aliquots by providing a simple, inexpensive, positive acting, and highly versatile liquid handling apparatus. Because of its simplicity,

the apparatus of the present invention is easy to maintain and clean, is highly reliable in operation and can readily be operated by unskilled, non-professional personnel.

Summary of the Invention

It is a primary object of the present invention to provide a simple, highly reliable and easy to operate liquid handling apparatus which can automatically aspirate, dispense and intermix various fluids with extreme precision.

More particularly, it is an objective of the present invention to provide a relatively simple easy to operate instrument designed to include a precision metering device that also functions in reverse as a sampling device. Due to the unique, simplified design of the device, high precision and accuracy in both modes of sampling and delivery can readily be realized.

It is another object of the invention to provide an apparatus of the aforementioned character in which the component parts which make up the apparatus are of clean design and can be manufactured of inexpensive, easily fabricated and readily available materials.

Still another object of the invention is to provide an apparatus of the character described in the previous paragraphs which embodies a minimum number of component parts and, therefore, is simple to clean and maintain.

A further object of the invention is to provide a device of the class described which makes use of prepackaged, disposable cartridges containing reagents or other liquids which can be readily installed by non-professional personnel with minimum system downtime and can then be discarded after use.

Yet another object of the invention is to provide an apparatus of the class described which permits simple rotational control of the liquid containing cartridge of the liquid metering

and aspirating device with relation to the stator member thereof through the use of an encoder reader or other digital control device, such as an optical or magnetic device, which provides precision control over both liquid dispensing and liquid aspirating by directly sensing the rotational movement of the liquid containing cartridge thereby eliminating all effects of backlash or slippage due to mechanical linkages.

Another object of the invention is to provide an apparatus of the character described which can be used as a reagent or therapeutic delivery system wherein the individual fluid filled cartridges can be individually programmed with precision to deliver on demand and in proper sequence, liquids either in a liquid dispensing or liquid sampling (withdrawal) mode.

Still another object of the invention is to provide an apparatus as described which can be used as a precision infusion device for fluid infusion to a patient via an access catheter.

Brief Description of the Drawings

Figure 1 is a generally perspective view of one embodiment of the liquid handling apparatus of the invention. Portions of the apparatus are enlarged, exploded and shown partially in cross-section to better illustrate the construction of the liquid metering and aspirating devices of the apparatus of the invention.

Figure 2 is an enlarged fragmentary view, partially in cross-section, taken along lines 2-2 of Figure 1 showing the encoder reader of the liquid metering and aspirating device used to identify the contents of the container and to instruct an ancillary computer system.

Figure 3 is an exploded side-elevational cross-sectional view of one form of the liquid metering and aspirating device of the present invention.

Figure 4 is a cross-sectional view taken along lines 4-4 of Figure 3.

Figure 5 is a perspective view of another embodiment of the liquid handling apparatus of the invention. Portions of the apparatus shown in Figure 5 are enlarged, exploded and shown partially in cross-section to illustrate the configuration of the liquid metering and aspirating devices of this form of the invention wherein a reader records movement of radial encoded lines provided on the closed end of the liquid cylinders.

Description of the Invention

Referring to the drawings and particularly to Figures 1 and 2, one embodiment of the liquid handling apparatus of the present invention is thereillustrated. The apparatus comprises a first rotatable carousel 12 for carrying a plurality of first liquid reservoirs 14, a second rotatable carousel 16 for carrying a plurality of second liquid reservoirs 18 and three liquid metering and aspirating devices 20 which are operably associated with the liquid reservoirs carried by carousels 12 and 16 via first and second transfer means, the details of which will presently be described.

Referring particularly to Figures 1 and 3, each of the liquid metering and aspirating devices 20 comprises an internally threaded hollow base member 22 having a bottom closure wall 24, a rigid stator, or upstanding hollow column, 26 mounted within base member 22 and an externally threaded liquid container, or disposable cartridge, 28 adapted to be threadably interconnected with base member 22 upon rotation of container 28 relative to base member 22. Each of the liquid metering and aspirating devices of the invention further includes a liquid delivery means for conducting fluid from the interior of the liquid container 28 to the exterior of the device and a non-rotatable plunger 30 reciprocat-

able movable a precise axial distance with respect to liquid container 28 upon rotation of the container 28 relative to the base member 22.

The plungers 30 of the liquid metering and aspirating devices each have sealing means adapted to sealably engage the inner wall 28a of the liquid container 28 for preventing leakage of fluid between the plunger and the inner wall of the container upon non-rotatable axial movement of the plunger 30 within the liquid container 28. Plunger 30 is also provided with connecting means for operably interconnecting the plunger with the stator 26 for preventing rotation of the plunger relative to the stator. Additionally, the plunger includes releasable locking means for releasably interconnecting the plunger with the stator to prevent relative axial movement therebetween during the aspirating mode of operation of the device.

In the embodiment of the invention shown in the drawings, the connecting means of each liquid metering and aspirating device is provided in the form of a cavity 32 which, as shown in Figure 4, is generally rectangular in cross-section and is adapted to closely receive the upper end portion of the stator, or upstanding column, 26. The interlocking means in this form of the invention comprises a resiliently deformable locking member 34, such as a molded detect or a thin metal spring or wire, which is receivable within a circumferentially extending groove 35 formed in cavity 32 of plunger 30. As will be discussed in greater detail hereinafter, when container 28 is rotated relative to base 22, the upper portion of stator 26 will be closely received within cavity 32. As this occurs, the resiliently deformable locking member 34 will frictionally engage and securely grip the side walls of stator, or column 26, thereby

the plunger 30 and the stator 26.

In each of the liquid metering and aspirating devices of the apparatus, the previously identified fluid delivery means is provided in the form of a tubular conduit 36 (Figure 3) which extends through an aperture 38 formed in bottom wall of base 24. The conduit then extends upwardly through hollow column 26 and then outwardly through an aperture 40 formed in the upper portion 26a of stator 26. Plunger 30 is provided with a fluid passageway 44 having one end communicating with the interior of the liquid container 28 and the other end communicating with the first, or upper, end 45 of conduit 36.

In the present embodiment of the invention, the previously identified sealing means of each liquid dispensing and aspirating device comprises a pair of spaced apart circumferentially extending skirts 50 and 52, the outer edges of which press resiliently against the inner wall 28a of container 28. While sealing skirts are shown in the drawings, it is to be understood that conventional type elastomeric O-rings could also be used as the sealing means.

Referring now to Figures 1 and 3, drive means are provided for controllably rotating each of the containers 28 of each of the liquid metering and aspirating devices. The drive means of each device here comprises a multiplicity of splines 56 provided about the periphery of the liquid containers, or cartridges, 28. A drive roller 58, also having a multiplicity of splines 60 provided about its periphery, is adapted to mateably engage and controllably drive the reagent containers 28. A motor means M is operably connected with drive roller 58 by a suitable driving connection 62. The details of the operation of the drive and control means of the present form of the invention will be

cribing the operation of the apparatus of the invention.

When the parts of the liquid dispensing and aspirating devices of the apparatus are mated in the manner shown in the exploded portion of Figure 1, rotation of reagent container 28 relative to the base 22 will cause the reagent container to travel downwardly in relation to plunger 30, which is fixed against rotation by the stator. Since the sealing means, or skirts 50 and 52, provided on plunger 30 prevents the fluid F contained within container 28 from passing between the plunger and the inner walls of the container, the fluid will be forced outwardly of the device through delivery tube 36. The amount of fluid passing through the delivery tube is precisely proportional to the travel of container 28 along the internal threads of base 22 as container 28 is rotated by the drive means. Accordingly, by closely controlling the rotation of the container 28, the delivery of the fluid from the device can be precisely and accurately controlled. More specifically, by providing very fine threads on the mating parts and through close control of the drive means or measurement directly from the container 28, high precision and accuracy in the delivery of small or large liquid aliquots can consistently be achieved.

Because the device embodies a minimum number of moving parts and due to the fact that the drive means is external of the unit and easily accessible, the device is highly reliable, readily maintainable and simple to operate.

Forming an important part of the liquid handling apparatus of the invention are transfer means which are operably associated with each of the liquid delivery means of each of the metering and aspirating devices and the liquid reservoirs 14 and 18 carried by carousels 12 and 16. The function of the transfer

the liquid delivery means of a selected metering and aspirating device and a selected one of the liquid reservoirs carried by the two rotating carousels. In the embodiment of the invention shown in Figure 1, a second transfer means is provided in the form of elongated conduits 64 which are interconnected via couplers 66 with the liquid delivery means, or conduit 36, of two of the liquid metering devices, namely the devices shown in the right hand portion of Figure 1. A first transfer means is, in this instance, provided in the form of a conduit 64 which is interconnected with conduit 36 of the remaining one of the liquid metering and aspirating devices by means of a connector 66 and a reservoir selection or transfer mechanism generally designated in Figure 1 by the numeral 68. Mechanism 68 includes an upstanding column 70 which is rotatably carried by a base 72. Affixed to standard 70 and extending perpendicularly therefrom, is an arm 74 which is adapted to carry a portion of the conduit 64 designated in Figure 1 by the numeral 64a. Column 70 is carried by base 72 to permit controlled up and down movement.

Another important feature of each of the liquid metering and aspirating subassemblies of the present form of the apparatus of the invention comprises control means for precisely controlling the rotation of container 28 relative to base 22 and for providing an automatic readout of the volume of fluid aspirated or dispensed. It is apparent that the travel of the plunger 30 is directly proportional to the extent of rotation of the container relative to the base. It is equally apparent that the amount of fluid aspirated or dispensed is directly proportional to the degree of travel of the plunger within the container. Accordingly, by controlling the rotation of the container relative to the base by a suitable control means such as a digital

and reads radially extending lines "L" provided on the top of the container, the amount of fluid dispensed can readily be controlled. The calculations of fluid dispensed as well as the instrumentation required to appropriately program and control rotation of the container relative to the base are well understood and will not be discussed in detail herein. However, by way of example, the control means can take the form of an encoder reader of a character well known to those skilled in the art. The control means can also take the form of a digital control device such as an optical or magnetic device which will provide for the precise control of rotation of the container and, therefore, precise control of the fluid dispensing and aspirating operations of the liquid metering and aspirating devices of the invention. As indicated in Figure 2, the digital control device designated "R" can alternatively be mounted on base 22 and be vertically movable within a slot 69 provided in the base 22. By various mechanical means understood by those skilled in the art, the control device "R" can be moved downwardly as container 28 is threaded into the base thereby causing continuous reading of the read marks B.

When multiple liquid metering and aspirating devices comprise subassemblies of the apparatus of the invention as shown in Figure 1, each device is provided with appropriate control means such as a digital control device of the character described in the preceding paragraph. These devices, when associated with suitable computerized equipment, provide means for controllably aspirating or dispensing precise quantities of liquids from the various cartridges 28 in predetermined sequences and in predetermined volumes. In a manner presently to be described, the control means of the invention further controls, via the first and second transfer means, the dispensing of liquid into, or the

withdrawal of liquid from, selected reservoirs 14 and 18 carried by carousels 12 and 16. In this regard, each of the carousels is provided with carousel drive means such as a roller 73 driven by a motor 75 via a shaft 78, or some friction, belt or other means of motion since close control or motion can be achieved by observing the position of the container 28 and not necessarily by motor position.

Turning now to Figure 5, an alternate embodiment of the liquid handling apparatus of the present invention is thereillustrated. In this form of the invention, the apparatus functions both as an infusion device and as an aspirating device. When used as an infusion device, precise amounts of a desired fluid can be infused into a patient via an access catheter. When used as an aspirating device, precise amounts of blood can be withdrawn from the patient for in vitro analysis. In this latter form of the invention the liquid metering and aspirating devices are of identical construction to that previously described herein and like numerals are used in Figure 5 to identify like component parts.

With the apparatus of the invention set up in the manner shown in Figure 5, three liquid metering and aspirating devices are used, each device having a liquid delivery means, or conduit, 36 which is in communication with the interior of liquid containers 28 of the devices. Each of the liquid delivery conduits are operably associated with delivery means, which, in this form of the invention, comprise connectors such as Luhr locks 71 which are interconnected with an elongated liquid manifold, or reservoir, 79 at spaced apart locations. Manifold 79 is in turn interconnected at one end thereof with an access catheter 80 of a character well known to those skilled in the art of the type used

use of control valves or other flow control devices. Disposed intermediate manifold 79 and access catheter 80 is an apparatus 77 for measuring blood chemistry. The purpose of this apparatus will be discussed more fully hereinafter.

The liquid metering and aspirating devices of this form of the invention operate in precisely the same manner as previously described herein. Each of the devices includes a externally threaded liquid container 28 which may be a pre-packaged disposable reagent container containing various types of reagents or other liquids. As was the case in the previously described embodiment of the invention, motor means M drive each unit and each is controlled by an encoder C which reads radial markings on each container or cartridge 28 to provide precision control of dosage and precise control of time intervals for metering a particular reagent from a given cartridge 28 through delivery means 36 to the reservoir, or manifold, 79. By preprogramming the drive means of the invention a single liquid, or a mixture of several liquids, contained in cartridges 28 can be delivered to manifold 79 and thence to the patient via access catheter 80.

Operation

In operating the apparatus of the embodiment of the invention illustrated in Figure 1, a container 28 in the form of a disposable reagent cartridge is inserted into base 22 of each liquid metering and aspirating device and the square hole provided in the plunger of the device is moved into locking engagement with the hollow stator, or stanchion, 26. Each conduit 36 is then threaded through the center of the square, hollow stator 26 to the exterior of the unit.

Upon rotation of a selected cartridge 28 by the motor M associated therewith, the external threads provided on the cart-

As the cartridge rotates, the bar code B provided on each cartridge is read by the bar code reader R where reader R is provided with a slot 69 which permits travel in concert with bar code B or where a reader such as reader C (Figure 1) is provided above container 28 so as to read bars created by splines 56 or like radial markings. In this way, control of motor M and the resultant rotation of each cartridge 28 can be automatically regulated.

The end 64a of conduit 36 of the liquid metering and aspirating device shown in enlarged form in Figure 1 is then interconnected with the transfer mechanism 68 in the manner previously described. Central column 70 of the transfer mechanism 68 has the ability to move up and down relative to base 72 as well as to rotate through an arc. Accordingly, a liquid sample can be selected, for example, from a reservoir 14 carried by carousel 12 and transferred to a selected reservoir 18 carried by carousel 16 and dispensed together with suitable diluent. It is to be understood that cartridges 28 of each liquid metering and aspirating device can contain various reagents or other liquids. For example, one cartridge 28 might contain a secondary reagent and another cartridge might contain a triggering substance.

As indicated in Figure 1, liquid from one of the cartridges 28 can be dispensed into a reservoir 14 carried by carousel 12 and a second liquid carried by the adjacent cartridge 28 can be dispensed into another reservoir as, for example, the reservoir designated by the numeral 18a in Figure 1. A third liquid can be added to reservoir 18a through use of transfer mechanism 68. For example, by rotating the transfer mechanism 68 so that the end of conduit 64a is over carousel 16 and then by rotating carousel 16 until reservoir 18a comes to rest beneath the free end of conduit portion 64a, liquid contained in the cartridge shown in enlarged form in Figure 1 can be dispensed

into reservoir 18a and mixed with the liquids previously dispensed therein from the remaining two cartridges 28 of the apparatus.

In yet another mode of operation of the apparatus of the invention, the transfer mechanism 68 can be positioned over carousel 12 and a selected reservoir 14 positioned beneath the free end of conduit portion 64a through rotation of carousel 14. The transfer mechanism can then be lowered so that the end of the conduit 64a is immersed into the selected reservoir 18 and fluid can either be dispensed into the reservoir by rotation of cartridge 28 in a first direction, or liquid can be withdrawn therefrom by rotating cartridge 28 in the opposite direction. With this unique arrangement, it is apparent that fluids can be selectively mixed in a given reservoir 18, or, alternatively, can be mixed within the cartridge 28. Because different liquids can be contained in the various reservoirs 18, it is apparent that any number of liquids can be controllably mixed to accomplish any number of desired reactions.

As previously mentioned, transfer mechanism 68 can also be rotated so that the end of conduit portion 64a is above one of the reservoirs 18 carried by carousel 14. In this position, fluid can be dispensed from cartridge 28, shown in enlarged form in Figure 1, or, alternatively, by lowering the transfer mechanism so that the free end of conduit 64 is immersed in liquid contained in one of the reservoirs 14, liquid can be withdrawn from the reservoir and mixed with liquid contained within the cartridge 28.

With the unique construction described in the preceding paragraphs and by the proper use of pre-programmed digital control devices, any number of liquids can be controllably mixed and

sels 12 and 16 as well as within cartridges 28 carried by the various liquid metering and aspirating devices of the invention. By proper programming of motors M and electrical drive means for driving carousels 12 and 16 in a manner well known to those skilled in the art and through use of appropriate digital devices such as bar code reader R and C, precise, controlled mixing of large numbers of liquids can be automatically and expeditiously accomplished.

In operating the apparatus of the embodiment of the invention illustrated in Figure 5, a container 28, for example, in the form of a disposable reagent cartridge is inserted into base 22 of each liquid metering and aspirating device and the square hole provided in the plunger of the device is moved into locking engagement with the hollow stator, or stanchion, 26. Each conduit 36 is then threaded through the center of the square, hollow stator 26 to the exterior of the unit.

Upon rotation of a selected cartridge 28 by the motor M associated therewith, the external threads provided on the cartridge will engage the internal threads provided on the base 22. As the cartridge rotates, the radial markings provided on the top of each cartridge is read by the encoder C. In this way, control of motor M and the resultant rotation of each cartridge 28 can be automatically regulated to provide precise control of dosage to the patient via manifold 79.

Reversal of the direction of rotation of any one of the cartridges 28 will cause blood to be drawn from the patient via the catheter. When the blood reaches the apparatus 77, measurements such as measurement of the blood electrolytes, blood gas analysis and the like can be made. Apparatus 77 can be of several different designs, but the apparatus disclosed in U.S.

present application. Reference should be made to this patent for the details of construction and operation of apparatus 77. Once the blood analysis is complete, the blood can be returned to the patient by rotating the selected cartridge 28 in the opposite direction.

Having now described the invention in detail in accordance with the requirements of the patent statutes, those skilled in this art will have no difficulty in making changes and modifications in the individual parts or their relative assembly in order to meet specific requirements or conditions. Such changes and modifications may be made without departing from the scope and spirit of the invention, as set forth in the following claims.

I CLAIM:

1. A liquid handling apparatus comprising:

(a) at least one first liquid reservoir;

(b) a liquid metering and aspirating device comprising:

(i) a threaded hollow base member having a bottom closure wall;

(ii) a rigid stator non-rotatable mounted within said base member;

(iii) a threaded liquid container adapted to be threadably interconnected with said base member upon rotation of said container relative to said base member, said container having an inner wall and a top closure wall;

(iv) liquid delivery means for conducting fluid from the interior of said liquid container to the exterior of the device; and

(v) a non-rotatable plunger reciprocally movable a precise axial distance within said liquid container only upon rotation of said container relative to said base member, said plunger having:

(1) sealing means adapted to sealably engage said inner wall of said liquid container for preventing leakage of fluid between said plunger and said inner wall upon non-rotatable axial movement of said plunger within said liquid container; and

(2) connecting means for operably interconnecting said plunger with said stator for preventing rotation of said plunger relative to said stator;

(c) first transfer means operably associated with said liquid delivery means of said liquid metering and aspirating device and said first liquid reservoir for transferring liquid between said liquid delivery means and said first liquid reservoir.

2. A liquid handling apparatus as defined in Claim 1 further including a second liquid metering and aspirating device and a second transfer means operably associated with said liquid delivery means of said second liquid metering and aspirating device and said first liquid reservoir for transferring liquid between said second liquid delivery means and said first liquid reservoir.

3. A liquid handling apparatus as defined in Claim 2 further including a second liquid reservoir.

4. A liquid handling apparatus as defined in Claim 3, further including:

(a) a rotatable first carousel for carrying a plurality of first liquid reservoirs; and

(b) a rotatable second carousel for carrying a plurality of second liquid reservoirs.

5. A liquid handling apparatus as defined in Claim 4 further including:

(a) first and second container drive means for controllably rotating said first and second containers of said first and second liquid metering and aspirating devices; and

(b) first and second carousel drive means for controllably rotating said first and second carousels.

6. A liquid handling apparatus as defined in Claim 5 further including locking means for releasably locking said plunger against axial movement relative to said rigid stator.

7. A liquid handling apparatus comprising:

(a) a first rotatable carousel for carrying a plurality of first liquid reservoirs;

(b) a second rotatable carousel for carrying a plurality of second liquid reservoirs;

(c) first and second liquid metering and aspirating devices each comprising:

(i) a threaded hollow base member having a bottom closure wall;

(ii) a rigid stator mounted within said base member;

(iii) a threaded liquid container adapted to be threadably interconnected with said base member upon rotation of said container relative to said base member, said container having an inner wall and a top closure wall;

(iv) liquid delivery means for conducting fluid from the interior of said liquid container to the exterior of the device; and

(v) a non-rotatable plunger reciprocally movable a precise axial distance within said liquid container upon rotation of said container relative to said base member, said plunger having:

(1) sealing means adapted to sealably engage said inner wall of said reagent container for preventing leakage of fluid between said plunger and said inner wall upon non-rotatable axial move-

ment of said plunger within said reagent container; and

(2) connecting means for operably interconnecting said plunger with said stator for preventing rotation of said plunger relative to said stator;

(d) first transfer means operably associated with said liquid delivery means of said first liquid metering and aspirating device for transferring liquid between said liquid delivery means and a selected one of said first liquid reservoirs of said first rotatable carousel; and

(e) second transfer means operably associated with said second liquid metering and aspirating device for transferring liquid between said liquid delivery means and a selected one of said first and second liquid reservoirs of said second rotatable carousel.

8. A liquid handling apparatus as defined in Claim 7 including means for controllably rotating each said container of each said liquid metering and aspirating device.

9. A liquid handling apparatus as defined in Claim 8 including means for controllably rotating said first and second carousels.

10. A fluid infusion and aspirating apparatus for controllably infusing fluids into and withdrawing fluids from a patient comprising:

(a) a fluid manifold having a plurality of fluid inlets;

(b) a plurality of liquid metering and aspirating

devices each comprising:

(i) a threaded hollow base member having a bottom closure wall;

(ii) a rigid stator mounted within said base member;

(iii) a threaded liquid container adapted to be threadably interconnected with said base member upon rotation of said container relative to said base member, said container having an inner wall and a top closure wall;

(iv) liquid delivery means for conducting fluid from the interior of said liquid container to the exterior of the device; and

(v) a non-rotatable plunger reciprocally movable a precise axial distance within said liquid container upon rotation of said container relative to said base member, said plunger having:

(1) sealing means adapted to sealably engage said inner wall of said liquid container for preventing leakage of fluid between said plunger and said inner wall upon non-rotatable axial movement of said plunger within said liquid container; and

(2) connecting means for operably interconnecting said plunger with said stator for preventing rotation of said plunger relative to said stator;

(c) a plurality of transfer means operably interconnecting each of said liquid delivery means of each of said liquid metering and aspirating devices with said fluid inlets of said fluid manifold for transferring liquid between said liquid delivery means and said fluid manifold;

(d) an access catheter operably associated with said liquid manifold.

11. A liquid handling apparatus as defined in Claim 10 further including means for controllably rotation each of said containers of each said liquid metering and aspirating device in a first and second direction.

12. A liquid handling apparatus as defined in Claim 11 further including means for measuring blood chemistry disposed intermediate said liquid manifold and said access catheter.

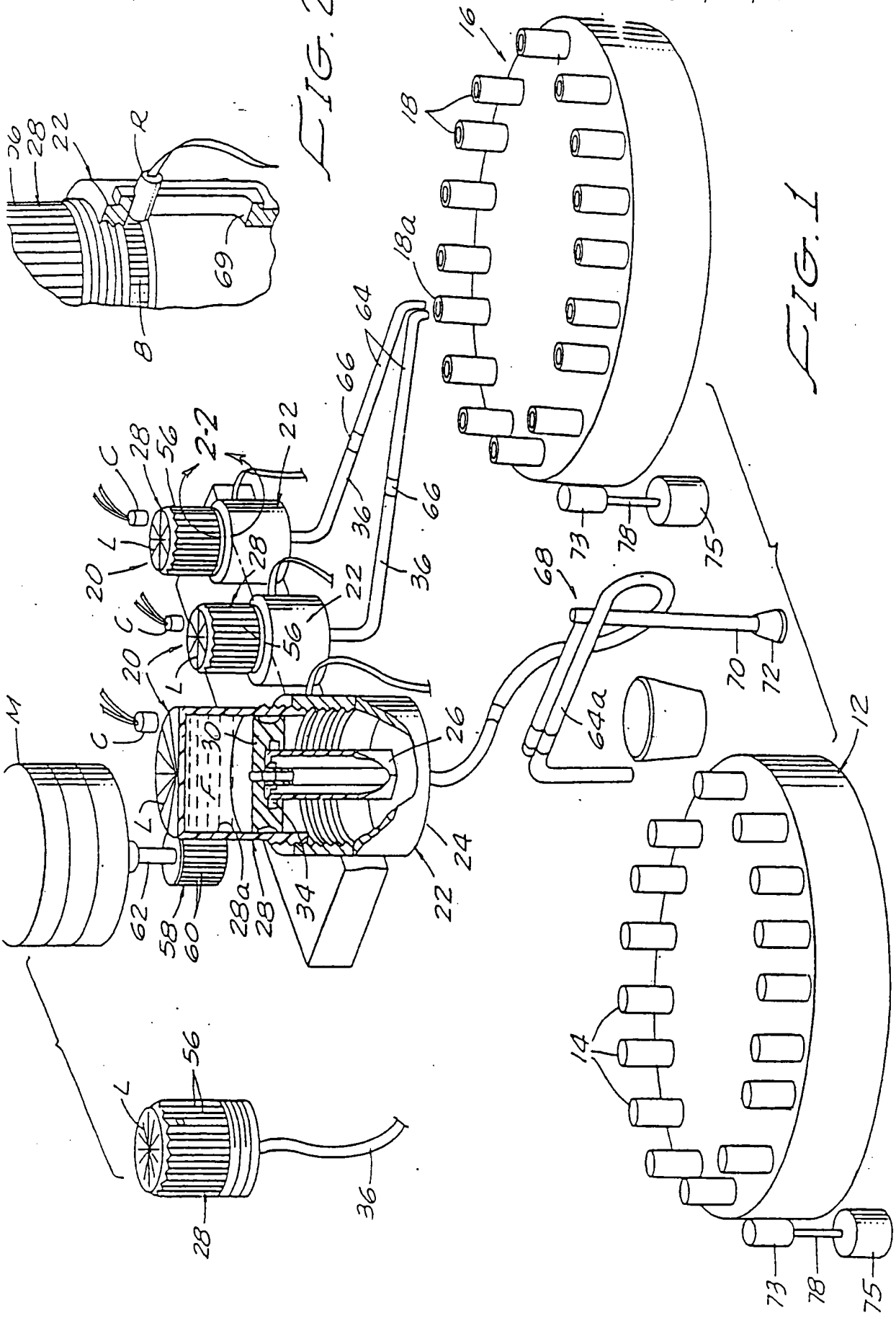
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FIG. 1

FIG. 2

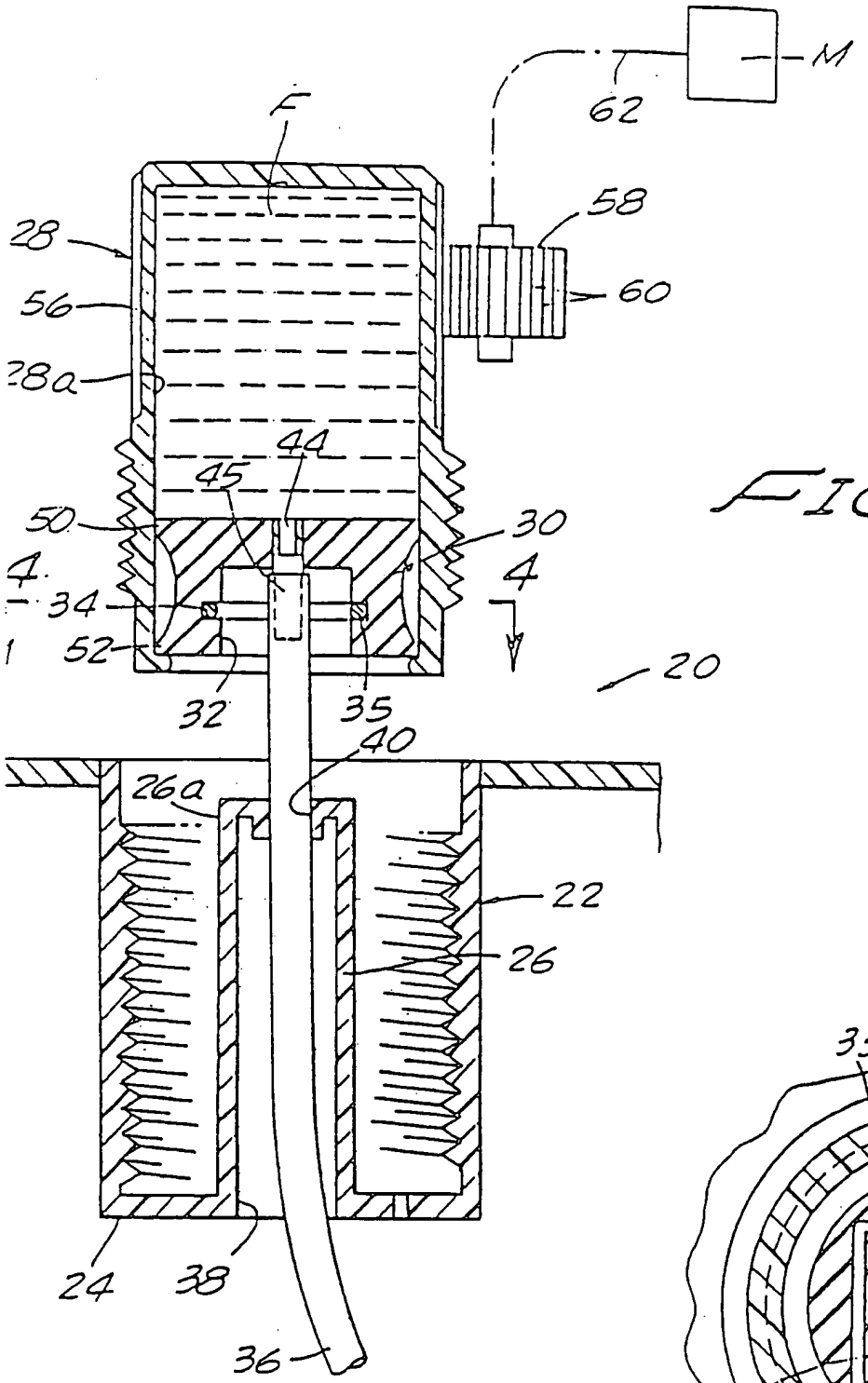
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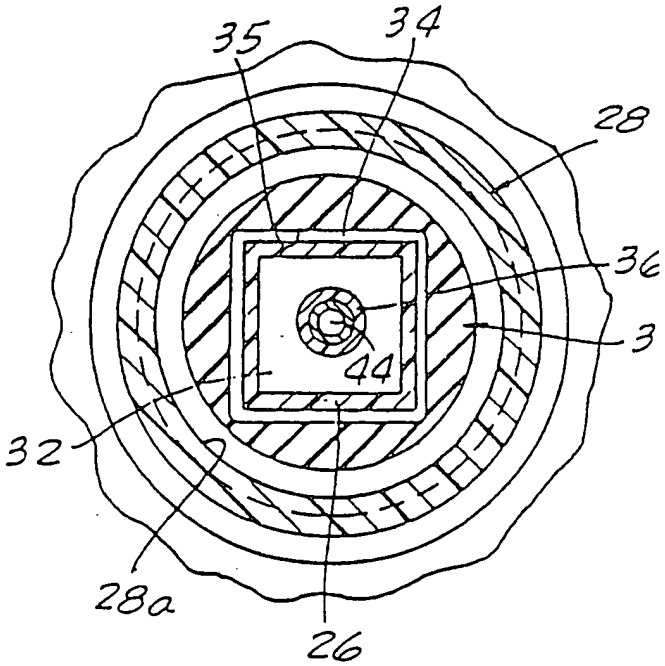
FIG. 3


35
34
28
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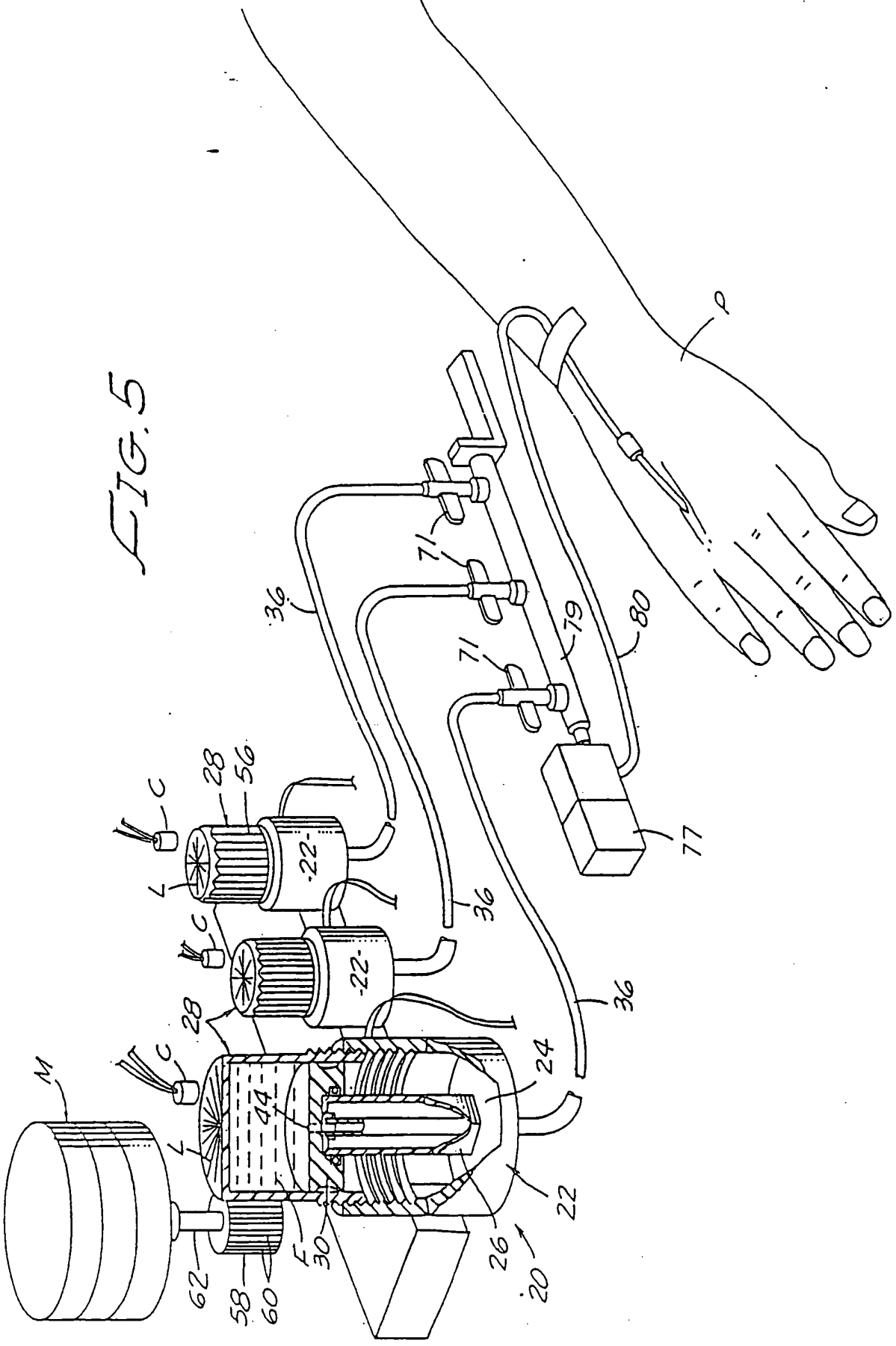
28a
26

FIG. 4

FIG. 5



INTERNATIONAL SEARCH REPORT

International Application No. PCT/US88/02800

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (4): G01N 1/14, 35/04, 35/06
U.S. Cl. 422/100, 102; 73/864.62; 222/390; 436 180

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	73/863.01, 864.11, 864.14, 864.16, 864.17, 864.62; 222/168, 333, 386, 390; 422/64, 99, 100, 102; 436/180

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
P,X	US, A, 4,738,826 (HARRIS) 19 April 1988 See the entire document	1-9
Y	US, A, 1,699,873 (BRODSKY) 22 January 1929 See the entire document	1-9
Y	US, A, 2,461,211 (GUTHRIE) 08 February 1949 See the entire document	1-9
A	US, A, 3,913,799 (DAVIS, JR.) 21 October 1975 See the entire document	1-9
Y	US, A, 3,615,240 (SANZ) 25 October 1976 See the entire document	1-9
Y,P	US, A, 4,699766 (YAMASHITA) 13 October 1987 See the entire document	10-12
Y	US, A, 4,543,238 (MIMURA) 24 September 1985 See the entire document	10-12

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
20 November 1988	19 JAN 1989

International Searching Authority	Signature of Authorized Officer
ISA/US	Robert P. Bell

Form PCT/ISA/210 (second sheet) (Rev. 11-87)

C 000623

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter [2] not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [3], specifically:

3. ☐ Claim numbers_____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [4]

This International Searching Authority found multiple inventions in this international application as follows:

I. Claims 1-9, drawn to a sampling/dispensing apparatus classified in Class 73, Subclass 864.17.

II. Claims10-12, drawn to a blood testing/injecton apparatus, classified in Class 128, Subclass 765.

1. X As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.